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# FABRICATION OF CdS/Si HETEROJUNCTION SOLAR CELL

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## ABSTRACT

To a make a low cost photovoltaic solar cell cadmium sulphide nanoparticles are prepared by a cost effective chemical method. The structure of synthesized nanoparticles is characterized by Transmission Electron Microscope and X-ray diffraction. Optical absorption and photoluminescence properties of as grown nanoparticles have been studied. The hetero junction of nanoCdS and p-Si has been fabricated from as prepared CdS nanoparticles. To prepare hetero junction device a film of CdS nanoparticles on p-Si has been grown by spin coating technique. The formation of CdS thin film on p-Si substrate is confirmed by AFM image. The current-voltage characteristics of the prepared hetero junction have been studied in dark and light condition. The measurement of efficiency and fill factor of the nanoCdS/p-Si hetero junction device are also performed.

**KEYWORDS:** CdS Nanoparticles, Structural Properties, Optical Properties, Hetero-Junction Solar Cell

## INTRODUCTION

The energy crisis in present time has led great interest in the research of renewable energy sources. The solar energy a kind of green energy is used enormously to confront the energy crisis. The current efforts are to increase the efficiency of photovoltaic devices [1-3]. The semiconducting nanoparticles are promising material for application in heterojunction, Schottky junction, quantum dot solar cell[4-9].The quantum confinement effect, surface to volume ratio of nanoparticles have changed the structural, optical, electronical etc. properties of nanoparticles from their bulk form[10-11]. Cadmium sulphide a grII - grVI semiconductor is an important material in photovoltaic devices, LED, Laser etc. [12-14]. CdS has band gap 2.42 eV in bulk form. There are different growth techniques to prepare CdS nanoparticles [15-17].

In this work a chemical reduction method is used to grow CdS nanoparticles [18]. The used method is simple and cost effective. The heterojunction of CdS nanoparticles with p-Si is fabricated. The prepared heterojunction device is also characterized. The current-voltage characteristics of the prepared heterojunction are studied under dark and illumination. The value of efficiency and fill factor of the nanoCdS/p-si hetero-junction device are determined.

## EXPERIMENTAL SECTION

The CdS nanoparticles have been synthesized using a chemical reduction method. Cadmium chloride, sulphur powder and sodium borohydride are used to grow CdS in the dispersive medium of tetrahydrofuran. The method of sample preparation is reported elsewhere [18, 19]. The structural and optical characterizations have been performed. The morphological and structural characterization of the as prepared samples is performed using transmission electron microscope and x-ray diffraction. The optical and photoluminescence properties of the as prepared samples have been studied.

The photovoltaic device of as prepared CdS nanoparticles with p-Si has been fabricated. The schematic of the prepared hetero junction is displayed in figure 1.

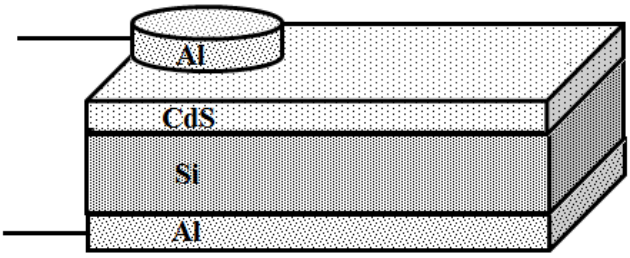


**Figure 1: The Schematic of the Prepared Hetero Junction**

The resistivity of used p- Si substrate is of the order of 5 Ω-cm. The Si substrate is cleaned by standard process followed by etching in 1% dilute hydrofluoric acid. To grow film of CdS nanoparticles on p-Si the CdS sample is dispersed in ethanol. Thin film of CdS nanoparticles is deposited on p-Si by spin coater. The prepared nanoCdS /p-Si heterojunction is backed for few minutes at 40°C.For electrical contact Al is deposited on nanoCdS film by vacuum evaporation. Contact area of Al deposition on CdS film is $4 \times 10^{-4}$ $cm^{-2}$. The current density –voltage characteristics of as prepared nanoCdS/p-Si heterojunction in dark and under air mass1.5 illumination (XES-151S) with power density with 100mW/$cm^2$ have been measured.

Agilent B1500A semiconductor device analyser has been used to perform the measurement of current and voltage of the prepared hetero junction.

## RESULTS AND DISCUSSIONS

The TEM image of as synthesized CdS nanoparticles is shown in figure 2.

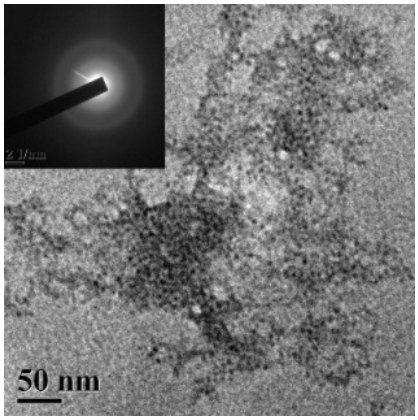


**Figure 2: The TEM Image and Sad Pattern of as Prepared Nanoparticles**

The grown nanoparticles are not agglomerated and the average size of the nanoparticles is found to be 8 nm.

The XRD pattern of the as prepared samples shows that the as grown CdS nanoparticles are in hexagonal phase.

The optical absorption spectrum of as prepared CdS samples is given in figure 3.

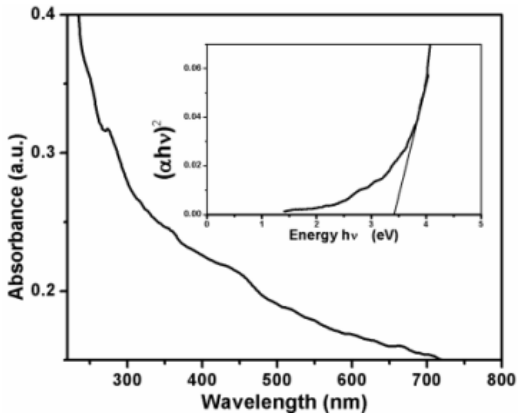


**Figure 3: Optical Absorption Spectrum of Cds Nanoparticles and Band Gap Determination (Inset)**

The band gap of the grown sample is determined from the $(\alpha h\nu)^2$ vshν plot, where α is absorption coefficient, h is Plank constant and ν is the frequency of light. The band gap of as synthesized CdS nanoparticles is found to be 3.42 eV.

The photoluminescence spectrum of as synthesized sample is shown in figure 4.

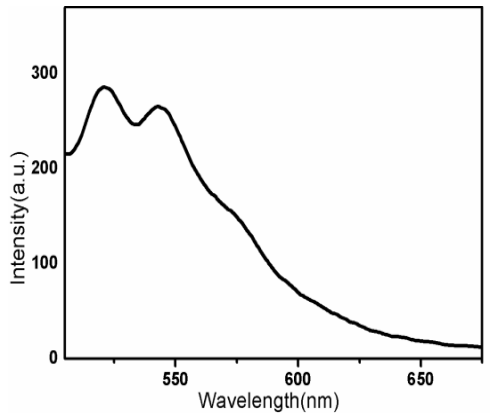


**Figure 4: Photoluminescence Spectrum of CdS Nanoparticles**

The peak of the spectrum is attributed to surface states [20-22].

The formation of thin film of CdS is confirmed through AFM image given in Figure 5

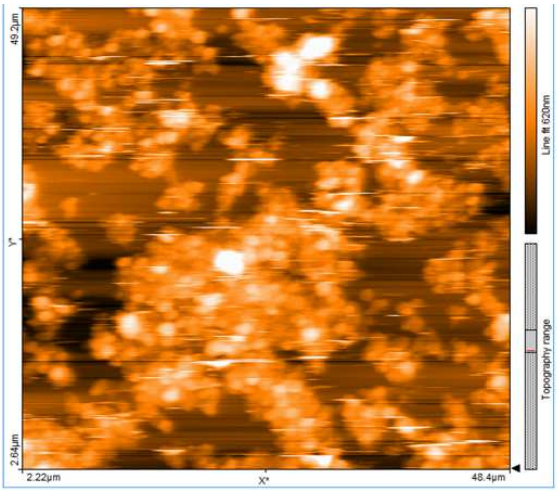

**Figure 5: The AFM Image of Thin Film of CdS**

Figure 6 illustrates the energy band diagram of heterojunction of nanoCdS and Si.

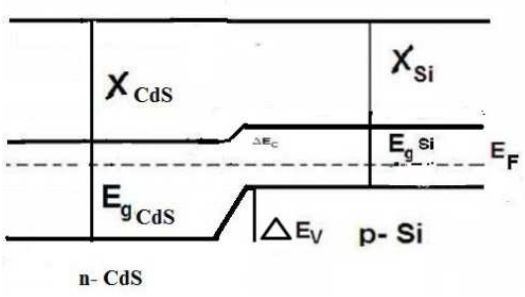


**Figure 6: Proposed Band Diagram of Heterojunction of Nanocds / Si**

The conduction and valence band edge are estimated using the relation $\Delta E_C = \chi_{CdS} - \chi_{Si}$ = (4.8-4.05) eV=0.75eV where $\chi$ is the electron affinity of the material, $\Delta E_g = (E_{CdS}-E_{Si})$ =3.42-1.12=2.3 eV where $E_g$ is the band gap of the material, $\Delta E_v = \Delta E_g - \Delta E_c$ =2.3-0.75 = 1.55eV [23, 24].

The current density (J) and voltage (V) characteristics of the as photovoltaic device have been investigated in the dark and light under different bias conditions. In the forward bias there is a shift of the J-V curve under light with respect to the dark. When light incidents on nanoCdS, the minority carrier holes are generated on n-CdS due to transition of electrons from valence band to conduction band. The holes constitute the photocurrent sensing electric field at the junction.

The different solar cell parameters short circuit current density $I_{sc}$, open circuit voltage $V_{oc}$, and maximum output power ($P_m$) have been determined.

The fabricated nanoCdS/Si photovoltaic device shows rectifying diode characteristics. The J–V characteristics under illumination AM 1.5 (100 mW/cm$^2$) of the device is displayed in Figure 7

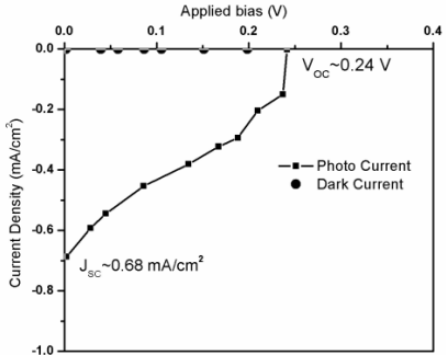


**Figure 7: Current Density (J) Vs Applied Bias (V) Characteristics**

Power conversion efficiency0.051 % is achieved for the cell having 50 nm layer of the device was measured using the relations:

$$FF = I_m V_m / I_{sc} V_{oc} \quad (1)$$

$$\eta = V_{oc} I_{sc} FF / P_{in} \quad (2)$$

Where $V_{oc}$ is the open-circuit voltage, $I_{sc}$ is the short circuit current, $FF$ is the fill factor, $\eta$ is the power conversion efficiency, $P_{in}$ is the incident light power density, $I_m$ and $V_m$ are the current and voltage at the maximum power point

respectively.

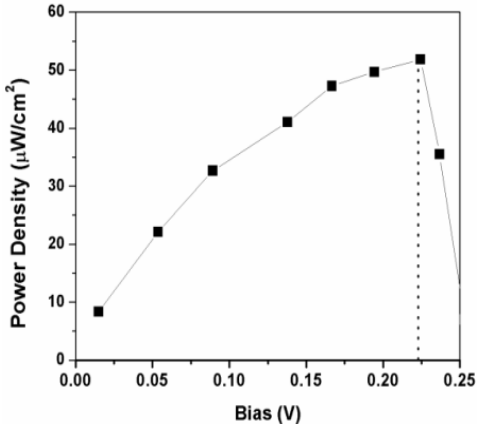


**Figure 8: Power Density Vs Applied Bias Graph**

The low efficiency of as prepared nanoCdS/Si heterojunction is probably due to the loss of carriers due to recombination within CdS layer [25]. This may be due to surface states present in the nanostructured CdS film which is evident through photoluminescence spectrum.

**Table 1: Different Parameters of CdS-Si Heterojunction Obtained from J-V Characteristics**

| $V_{max}$ | $J_{max}$ | $V_{oc}$ | $J_{sc}$ | Fill Factor | Efficiency |
|---|---|---|---|---|---|
| 0.22V | 0.23 $mA/cm^2$ | 0.24V | 0.68 $mA/cm^2$ | 31.29 % | 0.051 % |

## CONCLUSIONS

We have synthesized CdS nanoparticles for photovoltaic cell by a simple chemical method. We have fabricated a heterojunction of nanoCdS with p-Si. The current density-voltage characteristics of the fabricated device have been studied. The fill factor and efficiency of as prepared solar cell have been measured. The efficiency of the device is low due to presence of surface traps in nanoCdS.

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